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ABSTRACT

The scenario of instructional development presented makes a case for relying on recent refinements of the computer as a tool for giving form to human knowledge. The computer is described as having a high capability to form ideas into a variety of shapes, and vary those shapes to appeal to people's sense of abstraction. The history of the development of computer graphics is traced, numerous illustrations of computer generated graphic displays are provided, and some of the implications of computer graphics for people who specialize in the communication of ideas are explored. Four references are listed. (Author/CMV)

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COMPUTER GRAPHICS AND THE EDUCATOR:

NEW FORMS OF INVOLVEMENT FOR THE PRACTITIONER

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Paper Presented at the 10th Annual Conference on Visual Literacy
International Visual Literacy Association
Rochester, New York, November 8-11, 1978

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Computer Graphics and the Educator:
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It is obsolete now, according to the dictionary, but the word information has in the past meant "to give form to" -- connoting much the same as a squadron of jets flying in formation. It is hardly obsolete, however, whatever the dictionary may say, for educators to recognize the intimate connection between the form in which ideas are presented and the capacity of those ideas to inform! Communication theory rests to a large extent on the basic premise that form matters when it comes to people's ability to see and to comprehend.

Within the field of education, audio visualists/instructional developers have drawn into their shops a stockpile of tools, including audio and video recording, letter making and graphic art techniques, overhead and other reproductive, print-making devices, but the computer and computer-generated graphics have remained for the most part outside the realm of audio-visual departments. This paper presents a scenario of instructional development, which, on the one hand, makes a case for relying on recent refinements of the computer as a tool for giving form to

human knowledge, and which, on the other hand, extends somewhat and thereby reconceptualizes the work of the educator.

The paper first traces an brief history of the development of computer graphics, provides numerous illustrations of computer-generated graphic displays, exploring some of the implications of computer graphics for people who specialize in the communication of ideas.

History of computer graphics

Graphics is an old art. Broadly defined, it includes such diverse forms as architectural plans, anatomical sketches, sculpture and art, and maps -- a variety of "graphic" forms used to depict ideas about buildings, the human body, geography, and about humans and their conceptions of the world. What have changed over the years are the technologies available for "in-forming" ideas. Such advancements as photography, satellite communication, audio and video recording have had obvious implications for communicators. This section traces the development of computer graphics technology and its capability for "giving form to" information.

The history of computer graphics is parallel to the history of computers themselves. The growth of computer-produced graphics has its roots in three key developments in the computer technology: 1) development of more usable languages to address/control the machine; 2) introduction of remote job entry; and 3) the software "packaging" of often-used routines. Each of these three developments has simultaneously advanced computer graphics applications.

Development of computer languages. During the 50's, computer applications were largely number oriented: recording accounts receivable, storing and retrieving information, and computing research problems. The early languages used to instruct the machine where cumbersome by today's standards, but the ability of the machine to add or subtract numbers was sufficiently fascinating for mathematicians, economists, research and business people to spend their time developing more usable languages such as Assmebler, FORTRAN and COBOL. By developing more powerful ways of communicating with the machine, these people made the computer a valuable tool for business and research applications.

Computer graphics was first introduced in 1959 when CalComp produced the first drum plotter. This new piece of equipment made it possible to draw lines and circles. Although the visual forms caught on extremely fast and computer buffs began drawing fancy computer designs, the job of instructing the computer to make those lines remained a task only open to proficient FORTRAN programmers. Merely instructing the machine to pick up a pen and draw a line took such vast amounts of programming minutae as to make it impractical to use the graphics device except for somewhat eccentric applications. It is not by accident that one of the best-known spoofs on the computer is for a human to mimic the machine in jerky, robot-like movements -- move - hand - down, grasp pen, pick - up - pen, move hand to paper, put pen down, move pen right, move pen vertically, put pen down, and so on -- movements which flow from humans but require

hundreds of short, choppy movements for robots and early drum plotters.

Under such conditions, when the board of directors needed a plot the next morning of the fluctuating interest rate over the prior 12 months, for example, the secretary remained a far superior alternative to hours of FORTRAN programming. The drum plotter was used, therefore, only for very special projects -- e.g., an order of 100 plots all nearly the same -- or by very dedicated computer scientists who chose to spend large amounts of time to make computer-drawn figurines, or in later years, Snoopy figures. For general, short-term applications, however, secretaries or art departments continued to do the work while many drum plotters sat in the corner of the computer center, in the early 70's, sometimes holding a month-old printout that an operator had inadvertently forgotten to remove.

Compounding the massive programming required for communicating with the computer and drum plotter, there were persistent problems of errors and de-bugging. The recipe for submitting batch jobs keypunched on cards has produced bad memories for all users: take card deck to computer center; wait for three or four hours, or even two or three days; get back a listing with error message that a single missing comma kept the program from executing; go back to the keypunch, correct card; resubmit; wait another two or three days; get back another error message that in some way two cards became reversed; program did not execute; start over; . . . start over; . . . start over. Under such conditions, acceptance of computers themselves -- not to mention computer graphics -- was delayed.

Development of desk-top terminals. Besides the development of more usable computer languages and drum plotters, the development of the desk-top terminal gave users the capability of talking directly to the machine. Ten years ago, when Tektronix introduced the remote entry terminal in the form of a television-like screen connected to a keyboard, Programmers could enter commands, as the airlines currently do, directly from their desk -- interacting in much the same way that humans interact in conversation. Many of the potential obstacles in batch jobs, described above, were eliminated. Since programming was visible on the screen, users corrected mistaken entries, debugging as they went along, and only when they were satisfied that their program was workable, they would submit it to the hard-copy printer.

Graphics uses of the computer also took a big step forward with the ability of the user to preview and edit displays. An analogy might be made with the development of poloroid film: the graphic artist could take a "snapshot" of a display, make decisions about the appropriateness of the display, and improve the "rough draft" directly on the screen, e.g., by making the title a little larger, or moving it to the right or left, or by chainging the color shading, or removing unnecessary lines, or any number of modifications, including discarding the graph. When the piece of work was finally suitable, it was then sent to the drum plotter for final hard-copy printout.

Two problems persisted, however. First, early graphics produced on drum plotters were of such quality that it was generally necessary to cut and paste, to type in the titles and

legends, and finally to send the copy to the graphic arts department, encountering further delays. In the end, many times the final product turned out with a "fixed up" look, unless the graphics art department had spent hours in retouching the work, thereby rendering the computer production somewhat redundant.

The second problem has already been noted above. Even with desk-top terminals, computer languages were still cumbersome enough that it took more time to tell the machine where on the screen or page it was supposed to place a title than it took to ask a human to make a "properly titled" first page. The recent advertisement, "Congratulations, you know how to put your data into the computer," ended with the tell-tale punchline, "Now, how do you get it out again?" Until recent years, the sobering conclusion was that the graphics jobs could be done faster and better without the computer.

Development of software packages. Serious reliance on the computer for transforming data into communicable forms received little attention until about 1975, when computer scientists began to reason that if production of computer graphics was to become practical, some type language had to be developed that would treat the obvious as habitually as humans do. Similar to the way humans habitualize many aspects of their daily lives, reasoned the computer programmers, machines can be instructed to take for granted much of the routine work they were being asked to do. The programmers set out, therefore, to make it as routine for the machine to center titles at the top of the graph, for example, as it is for humans,

Several types of software emerged. Statistical packages made it possible to specify PROC FREQ; and the user received a frequency distribution for every variable in the data set, including the frequency, percentage, cumulative frequency, and cumlative percentages

NUMBER OF STUDENTS IN OUR SCHOOL -- BY SEX -- 1977-78

SEX	FREQUENCY	CUM FREQ	PERCENT	CUM PERCENT
FEMALE	1495	1495	56.29	56.29
MALE	1161	2656	43.71	1ØØ.ØØ

for each value of each variable in the data set -- all of this "properly spaced" on the page, and including a title, itself properly centered at the top of the page, if the user had entered another simple command, TITLE 'NUMBER OF STUDENTS IN OUR SCHOOL -- BY SEX -- 1977-78'; (See Barr, et. al., 1976).

Computer graphics took the same route, developing packages of frequently-used FORTRAN routines, which in effect instruct the machine to "take for granted" that the user wants titles centered at the top of the bar graph, and that the color or hatchwork used in the bars should match what is found on the legend -- unless otherwise specified.

The development of software packages, along with the introduction of new hardware, such as flatbed printers, color remote terminals, microfilm cameras, xerox color copiers -- all of which are capable of "talking" to each other -- has produced a network in which the graphic artist can preview a figure, rotate it to view from a number of angles, make modifications as they are necessary, select from seven

or eight color combinations, and then when the final product is judged to be suitable, send it off to the plotter, 33 mm camera, microfilm copier, or xerox copier for final copy.

The sophisticated, high-powered software packages have demonstrated that there are ways by which people with less than an hour of computer training can "get their data out again" in multi-colored figures, full-page reproductions, professionally produced graphic work.

Examples of graphic displays and some implications

Whatever else instructional developers might do, it is one of their primary professional activities to form, re-form and trans-form ideas into shapes capable of telling a story. The purpose of this section is to demonstrate the present capability of the computer to "in form" ideas into a variety of shapes, and to explore some of the ramifications of being able to vary those forms to appeal to people's sense of abstraction.

In the Harvard Business Review, George B. Blake (1978) sets the stage for computer graphics. After opening with the commonly heard complaint that "of all the frustrations of business life, surely one of the most aggreviating and persistent is the flood of paper," Blake reports his company's experimentation with varying the form in which information is presented. More noteworthy than his documentation of the proverbial "picture is worth a thousand words"

Exhibit II
Words and figures versus a graph

Words

The Mexican money supply maintained a fairly stable growth rate of about 20% per year for several years but began to increase more rapidly toward the end of 1976. It reached a peak growth rate of 33% in November 1976, but since then the expansion appears to have slowed. We predict a continued decline in the growth rate for the rest of 1977.

Figures

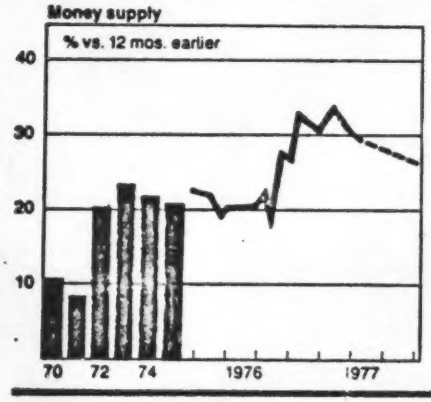
Money supply

Year	Percent of change from 12 months prior
1970	10.5%
1971	8.3
1972	21.2
1973	24.2
1974	22.2
1975	21.3

Month	Percent of change from 12 months prior, 1976	Percent of change from 12 months prior, 1977
January	22.1%	30.9%
February	21.7	32.7
March	18.4	31.2
April	19.8	29.8
May	19.7	28.7
June	19.6	29.5
July	20.9	29.0*
August	17.0	28.0*
September	27.1	27.5*
October	26.9	27.0*
November	32.9	26.8*
December	30.6	25.0*

*Estimate.

Graph

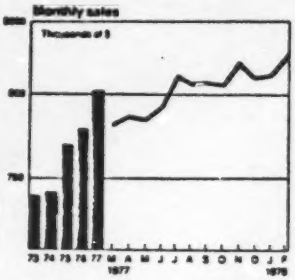


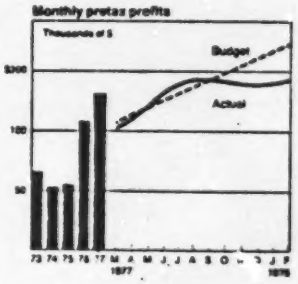
is the result of the company's experiment with just how much usable information they could place on a single page. With Exhibit I in hand, Blake reports "Now I get a better picture from just one sheet of paper . . . [with] 20 small graphs on it . . ." -- a page which he reports is readily usable in meetings or on trips or in telephone conversations.

Exhibit I
Corporate data (as of February 28, 1978)

Balance sheet

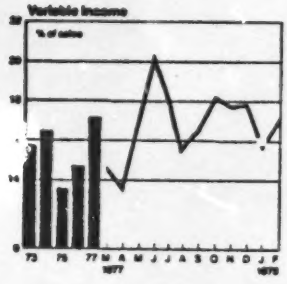
Assets		Liabilities	
Cash	$0.29	Pays.	$0.84
Recs.	2.40	A.L.	0.31
Inv.	2.39	S.T.D.	2.38
F.A.	0.46	L.T.D.	1.67
Misc.	0.67	S.E.	1.20
	$6.40		$6.40

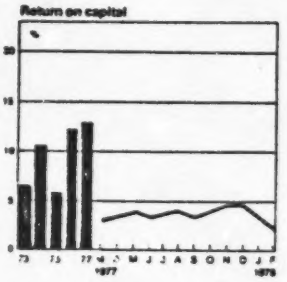


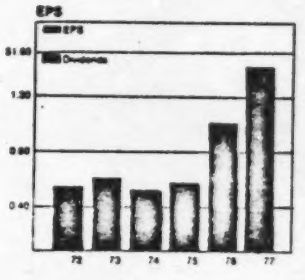


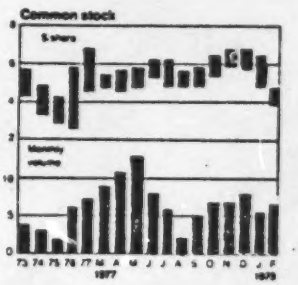
Division contribution to pretax profits (12 months)

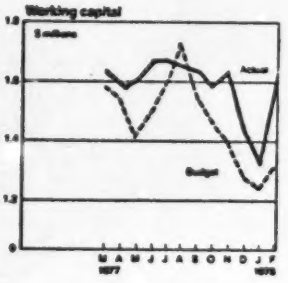
$000	Actual	Variance
S.M.C.	930	-15%
R.T.	841	-14
H.L.	488	+ 4

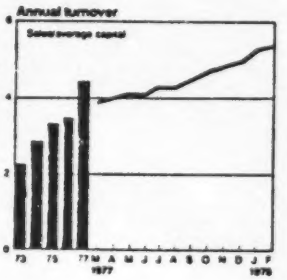


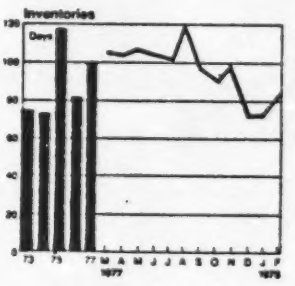


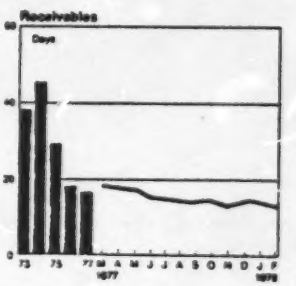


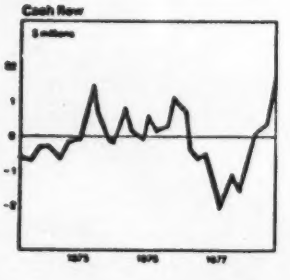


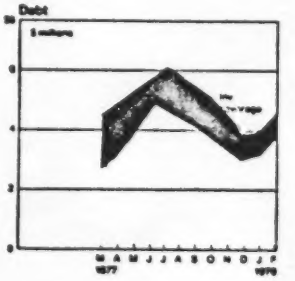


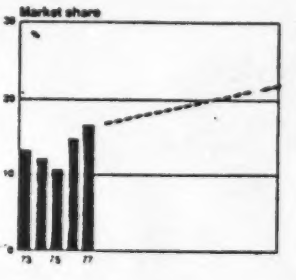


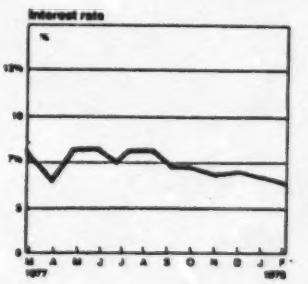


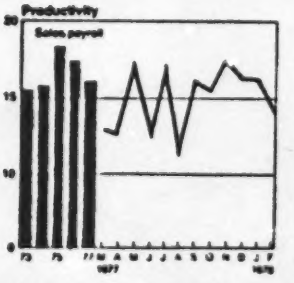


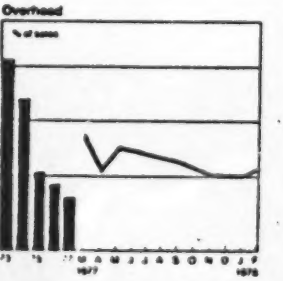


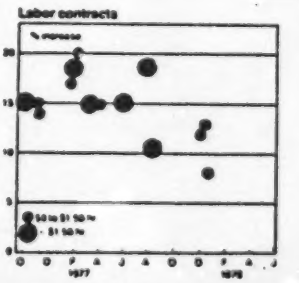


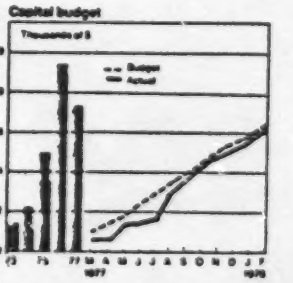




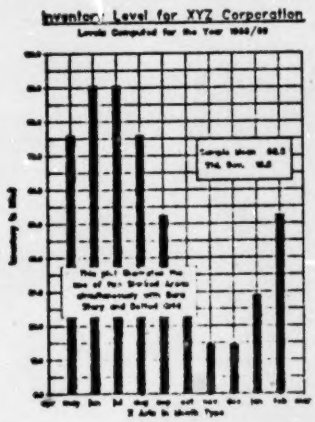




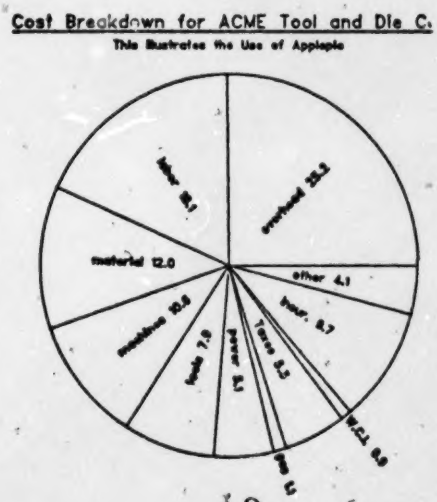




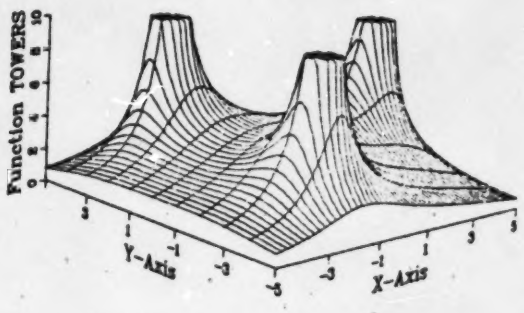
What is most crucial to realize at this point is that the technology exists to read complex data sets, to produce in seconds the individual graphs that Blake uses, and to complete the work with minimal intervention from the media specialists. Simple changes in commands can move from



a bar graph comparing April - March inventory levels for a particular corporation to a similar pie chart depiction of the same information, or if these forms do not appeal



to the sense of abstraction of those who ultimately have to make sense of the information, five or six other commands produce a three-dimensional characterization that demonstrates to company officials, for example, that the amounts of sales were particularly high during particular months in three of their branch offices.



Even the size and character of the lettering placed on posters or tables is totally under the control of the user. User commands (listed on the left) are the only commands needed to produce the different shaded fonts displayed on the right.

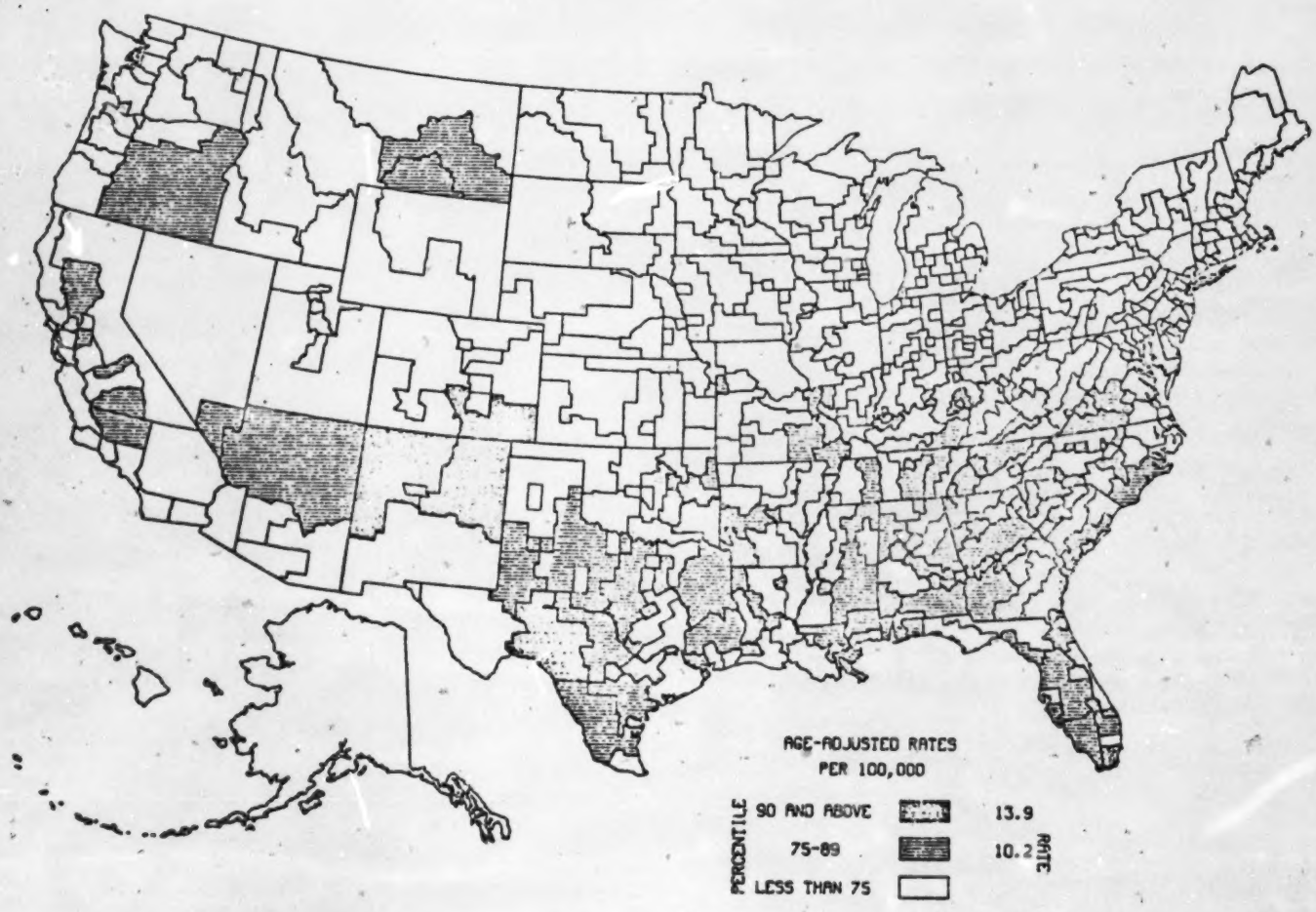
SHADED FONTS – High Resolution Character Sets

```
CALL SHDCHR(45.,1.,.01,1)
CALL FUTURA
CALL MESSAG('DISSPLA',7,X(1),Y(1))
CALL SERIF
CALL MESSAG('DISSPLA',7,X(2),Y(2))
CALL FASHON
CALL MESSAG('DISSPLA',7,X(3),Y(3))
CALL LOGO1
CALL MESSAG('DISSPLA',7,X(4),Y(4))
```

DISSPLA
DISSPLA
DISSPLA
DISSPLA

If faculty in health care would like to have census data analyzed for homocide rates for white males in the United States, by Sea, from 1969-71, the curriculum specialist enters minimal commands and produces a map of the United States with areas shaded or colored according to the needs of the health care faculty. If

HOMOCIDE FOR WHITE MALES BY SEA:
UNITED STATES, 1969-71



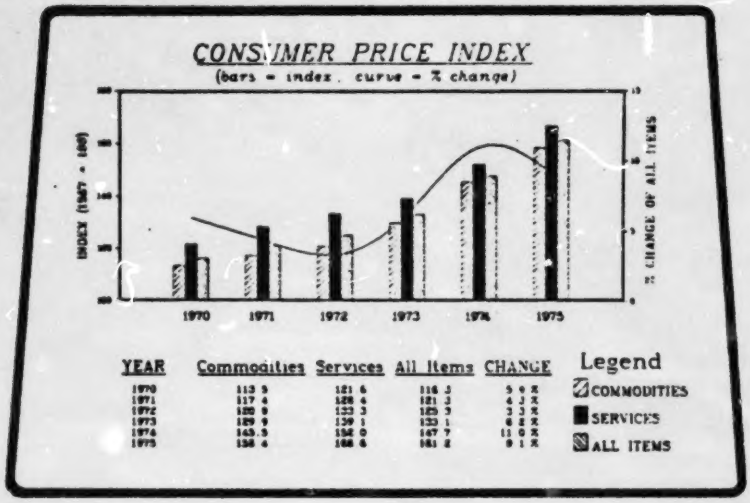
the color scheme or hatchmarks appear culttered, a second or third draft of the final product can be produced within minutes. Simple changes to white females, for example, produces an entirely different picture of homocide in the United States.

If a geography teacher requires a map of a particular country in the United States or particular coordinates in Europe, the commands listed at the left produce the framed, titled, colored map of a particular coastline in Europe. Simple specification of the desired coordinates produces maps of any geographical area.

MAPPING – World Coastline Utilities

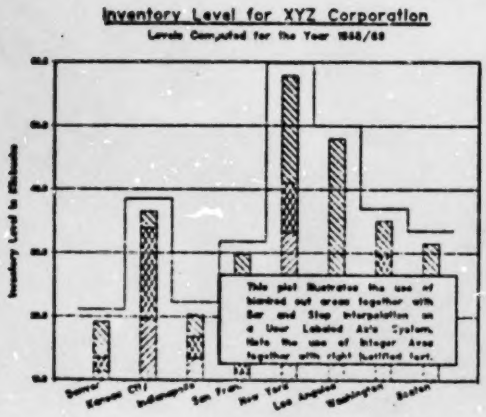
```
CALL TITLE('EUROPE',6,0,0,0,0,2.,2.)
CALL MAPGR(-30.,10.,50.,30.,10.,70.)
CALL FRAME
CALL MAPDTA
```

The most critical advance in computer software has been the ability to address the machine in plain English. In order to visualize complex relationships in the comsumer price index over a six year period, the user types on the terminal,



"MY X LABEL IS INDEX (1979 = 100). I WOULD LIKE TO HAVE TICK MARKS ON THE SIX-MONTH INTERVALS. GENERATING A BAR CHART. . . MY TITLE IS 'CONSUMER PRICE INDEX' I WOULD LIKE TO HAVE A SECOND LINE IN MY HEADING SAYING '(BARS = INDEX. CURVE = % CHANGE)'; I WOULD LIKE TO HAVE . . . MY DATA ARE...GO."

What if a faculty member brings to instructional developers the request for an economics class that depicts inventories for corporations in Denver, Kansas City, Indianapolis, San Francisco, and a number of other cities? Within minutes after the requests are entered, the computer analyzes the data and transforms the data into a bar graph.



With a little imagination, it is possible to think of computer graphics as the "flick" of a poloroid camera. In any of the above graphic depictions, the instructional developer can take a look at the color combinations and change from one set of hues to another by simply requesting a different color combination. If the hatch-marks on the table seem to clutter more than inform, they can be removed, and redrawn or colored in. The screen presents depictions analogous to rough drafts of a text, which can be edited, and remade to the satisfaction of the faculty members, students or administrators whom the data ultimately have to serve.

To guard against the impression that computers are limited to "make a bar graph" mentalities, or that the whole enterprize is a based on a race between graphic arts departments and the machine, two additional examples are needed to move the discussion into more complex issues.

Production of publication-ready work usually involves many people to take a piece of work from conception to the final copy. It is the usual practice to produce text with a typewriter and to produce art work as a separate step. In the end, the two are interwoven. This practice works fairly well in cases in which there is much text and few illustrations, but a mathematics or geography department might call for whole pages of formulas or maps.

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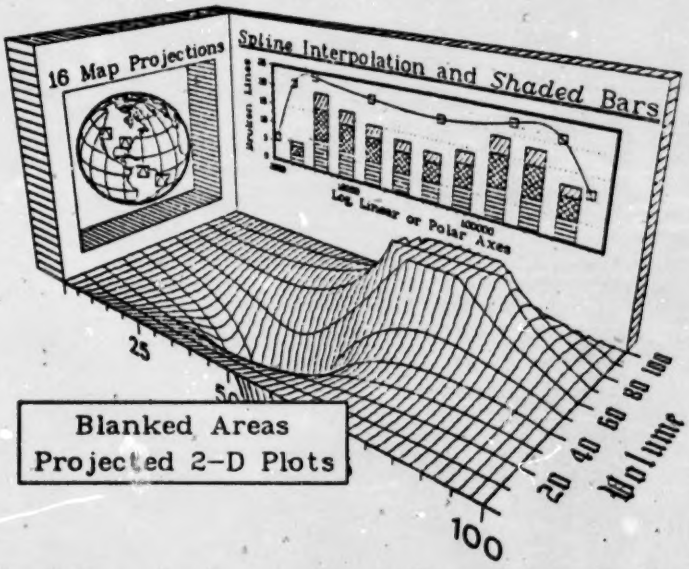
Display Integrated Software System and Plotting LAnguage



Our Machine Independent Graphics Software Leaves You To Your Own Devices

...yet is Easy to Use.

Machine Independent

DISSPLA is now working on : (a) IBM 360/370 using OS, DOS, TSO, VS, CMS, etc. ; (b) CDC 6000, 7000 or Cyber 70 series using SCO PE or KRONOS ; (c) UNIVAC 1100 series using EXEC 8 ; (d) PDP-10 using DECsyst em-10 ; and (e) XDS Sigma 9 using Commander II, and has been fully operational since 1969.

Device Independent

DISSPLA plots on Calcomp, Zeta, H. L. Hewlett Packard, Broomall, Xynetics and Gerber plotters ; FR80, SC4020, SC4060, and Singer microfilm recorders ; Tektronix, Vector General, and Computek CRTs ; and others. DISSPLA interfaces easily to any vector-mode graphics device.

Easy to Use

DISSPLA is a powerful package of FORTRAN subroutines called from the application program of the user. DISSPLA is to the basic plot ter software what FORTRAN and COBOL are to Assembly Language.

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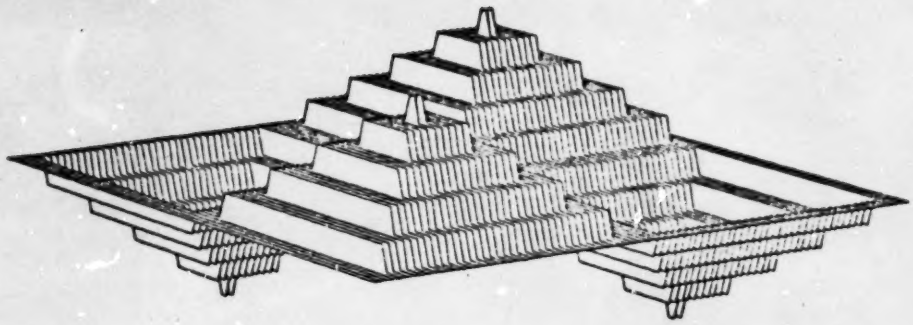
The best alternative has been to send the job to the typesetter for professional copy, but because typesetters may not be familiar with the specific scientific formulas, errors often appear.

With a Textronix scope authors of papers can sit for relatively short periods of time and produce whole pages of formulas. If, for example, a group of instructional developers is formulating an advertisement for DISSPLA® (see prior page), the computer will display the entire page on the screen. If the group decides that the Old English font should be changed to another, or that there is too much space between ". . .yet is easy to Use " and the words MACHINE INDEPENDENT, the computer changes the lettering to another style and moves the text downward to suit the design sensibilities of those creating the advertisement. The fast turn-around time makes it feasible to juggle whole pages of information, focusing on segments at a time, until the artist judges the production to worthy of the hard copy printer.

The last illustration moves beyond "reporting" and "depicting" functions in which the users know beforehand exactly what they want: the coordinates they want for maps, the titles they want put at the top of a graph, the letters they want to blow up for postures. What happens, however, when people using computer graphics do <u>not yet know</u> what will appear at the point of making a request? Computer graphics makes it relatively easy to imagine the surprise of a researcher using three dimensional figures to depict Pearson R correlations, for example, with their positive



and negative correlations depicted by the height of the "mountains" and "valleys". The marriage of conventional statistical applications and computer graphics is quite underdeveloped. How would an analysis of variance appear on the screen? What form would make the results of multiple regression unmistakeably clear to a statistics class? Such questions raise many possibilities for addressing the ever-present concern with how to formulate those fleeting aspects of human existence, which although they have structure (Berger and Luckmann, 1966) have never been put into forms capable of delivering their messages with clarity.

Conclusion

What is at stake in this discussion are the basic means by which people see and know (Feinberg and Franklin, 1975). . .In the past, authors, teachers, and textbook publishers took the responsibility for selecting a visual form, and then others (readers, students, learners) would follow after in a different -- and some would say, more passive -- role to interpret what the authorities had placed in front of them. The incipient theme of this presentation is that vast constituencies might take a direct part in determining the forms through which they view their realities -- a type of democratization of the knowing process. The media specialist task will probably remain much the same as it has always been -- setting up ideas into forms that make "the things" of human existence speak with clarity and decisiveness, but having business people, faculty members, student, parents and teachers sitting at the "drafting table," making requests that meet their own interests, and being able to respond all those interests in a matter of seconds, prompts some re-thinking of the basic foundations of instructional development.

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